Automotive Lightweighting Materials Program

Developing light, fuel-efficient, safe, affordable automobiles

ENERGY EFFICIENCY AND RENEWABLE ENERGY

OFFICE OF TRANSPORTATION TECHNOLOGIES

Transportation

FOR THE 21ST CENTURY

The Automotive Lightweighting Materials (ALM) Program of the Office of Transportation Technologies is developing and validating advanced materials technologies that will significantly reduce automobile weight without compromising vehicle performance, safety, recyclability, or cost. By fiscal year (FY) 2000, the ALM program had developed and validated materials technologies that, if implemented, would enable a reduction in automobile body and chassis weight of 50 percent relative to a 1994 baseline automobile, at 1.5 times the cost of using the baseline materials, while maintaining safety, reliability, and recyclability. By 2004, the ALM program is seeking to improve materials technologies that could enable a 50 percent reduction in the weight of automobile body and chassis components and a 40 percent reduction in the overall vehicle weight, while achieving cost-competitiveness with conventional materials.

The ALM program is pursuing five areas of research, including cost reduction; manufacturability; design data and test methodologies; joining; and recycling and repair. As the greatest barrier to the use of lightweighting materials is cost, priority is being given to reducing costs through the development of materials, forming technologies, and manufacturing processes. Priority materials include aluminum, magnesium, titanium, and composites, such as metal-matrix and glass- and carbon-fiber-reinforced thermosets and thermoplastics.

Collaboration and cooperation

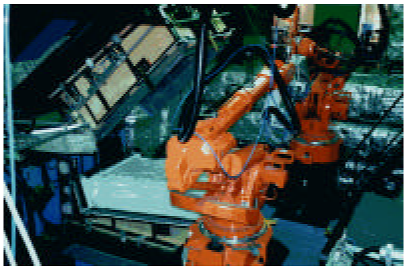
The ALM program team collaborates extensively with industrial partners such as the U.S. Council for Automotive Research (USCAR), that includes entities of the companies DaimlerChrysler, Ford, and General Motors, in order to identify and select its research and development (R&D) activities. These industrial partners also include the Automotive Composites Consortium (ACC), and the United States Automotive Materials Partnership (USAMP). The ALM program team will be an integral part of the new FreedomCAR Research Partnership announced in January 2002. Collaboration provides the means to determine critical needs, identify technical barriers, and select and set priorities for projects. Once selected, projects are pursued through a variety of mechanisms, including cooperative research and development agreements (CRADAs), cooperative agreements, university grants, research and development subcontracts, and directed research. This flexibility allows the program management to select the most appropriate partners to perform critical tasks.

Accomplishments

Research conducted under the Automotive Lightweighting Materials Program maintains a balance between the program's near-term goals and the higher-risk research needed to achieve longer term objectives. To meet these goals, the ALM program is developing materials and materials processing technologies; validating these technologies through fabrication and evaluation of representative, nonproprietary test components; and developing adequate design data to facilitate their beneficial application. As technical barriers are overcome, the technology is made available to industry. Use of these lightweight, high-performance materials will contribute to the development of automobiles that provide three times better fuel efficiency, yet are comparable in size, comfort, and safety to today's family vehicles.

Low-cost fiber composites

One of the highest priority technical needs is the development of low-cost carbon fibers. Carbon fiber composites are the lightest material available for making primary automotive structures, and could reduce the body and chassis weight of vehicle components by more than 60 percent. Their use in the auto industry is limited, however, due to cost. Studies are currently underway to address the cost issue by exploring the use of advanced polymers, as well as coal and lignin, as possible precursor materials. Alternate methods for producing carbon fiber from those precursors are also being tested. These methods include the use of microwave



P-4 Carbon Fiber Preformer

Cast Aluminum Control Arm — Conversion to cast aluminum lowers weight of control arm from 16.3 to 7.9 lbs.

processing which has been shown to reduce production costs by 40 percent while cutting production time by nearly a factor of ten.

A project to develop advanced preforming techniques using glass fiber has been completed and demonstrated at the National Composites Center in Kettering, Ohio. Using a new preforming technology named P-4, glass fiber preforms, the size of a pickup truck bed, were made in less than four minutes with only 2 percent scrap, while changing fiber size and direction in various locations of the part being manufactured. The first commercial application of the new P-4 technology is to manufacture the pickup box in the 2001 Chevrolet Silverado. Modifications have begun on the P-4 preformer to allow for the manufacture of parts using carbon fiber.

Low-cost aluminum alloy sheet

One of the highest priority projects sponsored by the ALM program was the development of low-cost, continuously cast aluminum alloy sheet. Since aluminum sheet can find application in many body and chassis components, there is a critical need to implement new manufacturing processes that can lower its cost. Initial tests with continuously cast sheet aluminum have indicated that it can be produced for 10-25 percent less cost than traditional cast ingot-rolled sheet. Follow-on work in this area is now being planned.

Cast light metals

Technology has been developed to assess the criticality of defects in aluminum castings and to prevent the occurrence of those defects. A database of cast aluminum's properties has been developed and is currently being used by industry to aid in component design. A simulation model for solidification and microstructure has also been developed, the use of which has already been implemented by commercial aluminum casters. These projects have enabled the conversion from a nodular iron control arm weighing 16.3 lbs. to an aluminum component weighing just 7.9 lbs. The aluminum-focus portion of this effort has been completed and is being replaced with a similar one for magnesium.

Composite mixing technology

A major accomplishment of the ALM program has been the development of a unique modular composite mixing technology that eliminates the costly remelting of metal matrix composite materials (MMC). The modular MMC composite process greatly reduces the time and cost needed to produce MMC materials. This will allow foundries to mix and cast these light-weighting composite materials on the foundry floor. A follow-on project is examining the use of this technology to manufacture lightweight braking systems.

Magnesium and magnesium alloys

The ALM program is supporting efforts to reduce the cost of primary magnesium, an important lightweight metal. One approach that is being explored is direct reduction of magnesium oxide using a solid-oxide, oxygen-ion-conducting, membrane-based electrochemical process. This technique has the potential for reducing the cost of primary magnesium production to that of aluminum. Also, the ability to mold lightweight magnesium alloys into complex shapes now holds the possibility of replacing heavier metals in automotive components. The ability to produce components that can operate at elevated temperatures offers the potential for increased usage of lightweight magnesium alloys in many under-hood applications, resulting in substantial weight savings.

Future directions

In the first five years (1994-1998) of the Partnership for a New Generation of Vehicles (PNGV), the ALM program focused mainly on aluminum sheet production and forming, aluminum casting, and fabrication of components from glass fiber-reinforced thermoset polymer-matrix composites. In 1999 and 2000, the portfolio of projects was rounded out to include R&D on magnesium metal production; titanium metal production; casting of aluminum-matrix composites; weight reduction of glass-reinforced composites; production of carbon fiber, thermoplastic polymer-matrix composites; crashworthiness modeling; and recycling, reuse and repair. While those previous efforts conclude or continue apace as appropriate, the R&D focus under the FreedomCAR Research Partnership is shifting towards issues of cost-effectiveness and manufacturability of automobile components from those materials.

For more information on how DOE is helping America remain competitive in the 21st century, please contact:

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